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KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES

COMMON TEST

JUNE 2022

TIME: 2 hours

MARKS: 100

This question paper consists of 10 pages and 2 data sheets.

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INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name on the **ANSWER BOOK.**
2. This question paper consists of **EIGHT** questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two subsections, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera where required.

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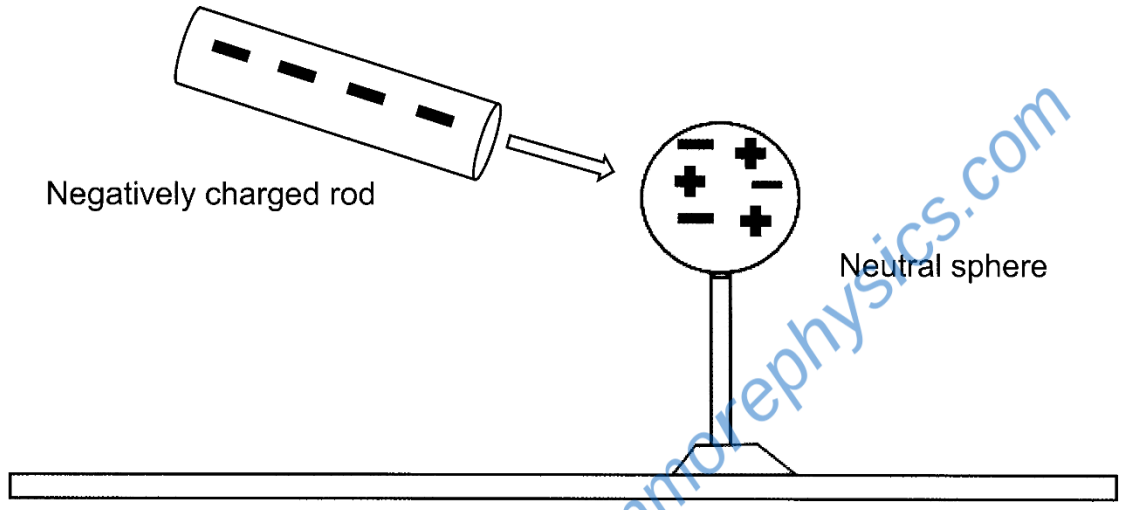
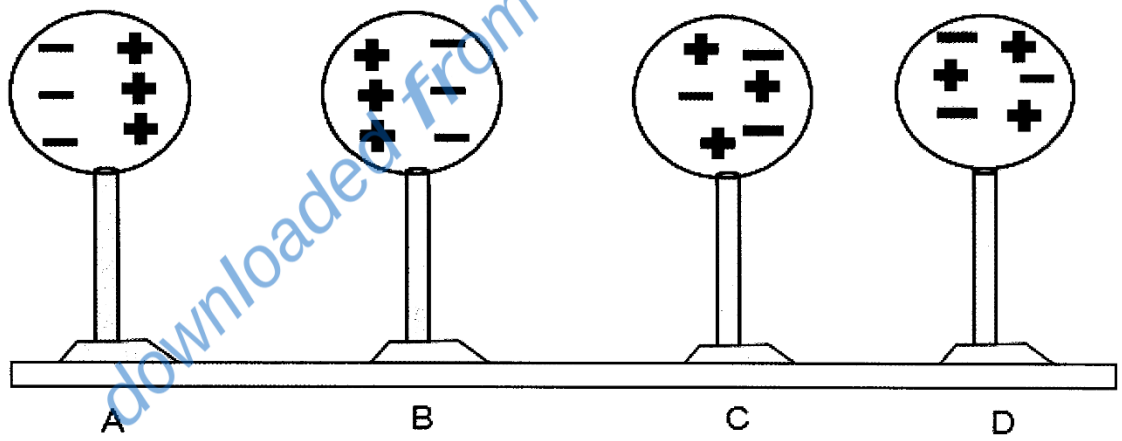
QUESTION 1: MULTIPLE CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A - D) next to the question number (1.1 — 1.6) in the ANSWER BOOK, for example 1.7 D.

1.1 A negatively charged rod is brought near a neutral conducting sphere placed on an insulating stand as shown below.



Which one of the diagrams below best describes the distribution of charge in the sphere when the rod is held close to the sphere?



(2)

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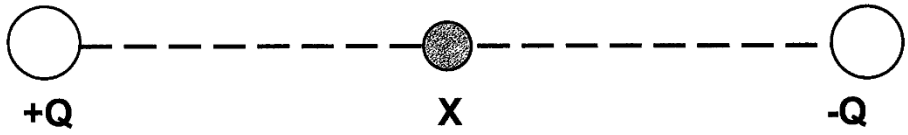
1.2 A small POSITIVE charge X is placed midway between a positively charged sphere with a charge of +Q and a negatively charged sphere with a charge of – Q. The three charges lie in a straight line, as shown.



The force that +Q exerts on X is F.
The magnitude of the net force experienced by X is .....

A F
B 2 F
C 0
D ½ F (2)

1.3 The magnitude of the electrostatic force experienced by a charged particle in an electric field depends on the…

A charge of the particle
B velocity of the particle
C mass of the particle
D direction of the electric field (2)

1.4 The forces of attraction between organic molecules of methane (CH_4) are:

A Hydrogen bonds
B Dipole-induced dipole
C Dipole-dipole
D London forces (2)

1.5 The number of moles of sodium ions in 87,75g of sodium chloride is:

A 2
B 0,67
C 3
D 1,5 (2)

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1.6 The number of H atoms in 3 moles of NH_3 is:

A 3

B 9

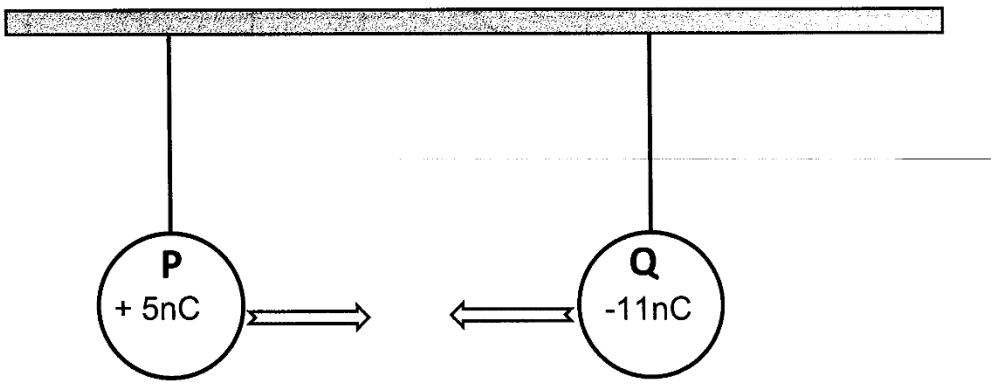
C $9 \times 6{,}02 \times 10^{23}$

D $3 \times 6{,}02 \times 10^{23}$ (2)

[12]

QUESTION 2

Two identical spheres, P and Q having charges + 5nC and –11nC respectively are suspended by insulated threads from a ceiling, as shown in the diagram below.



It is observed that the spheres initially swing towards each other, make contact and then move away from each other.

2.1 Explain why the spheres swing towards each other. (2)

2.2 State the principle of Conservation of Charge. (2)

2.3 Calculate the new charge on each sphere . (2)

2.4 Which of the spheres, P or Q, loses charge upon contact? (1)

2.5 Calculate the number of electrons transferred when the two spheres are in contact. (3)

[10]

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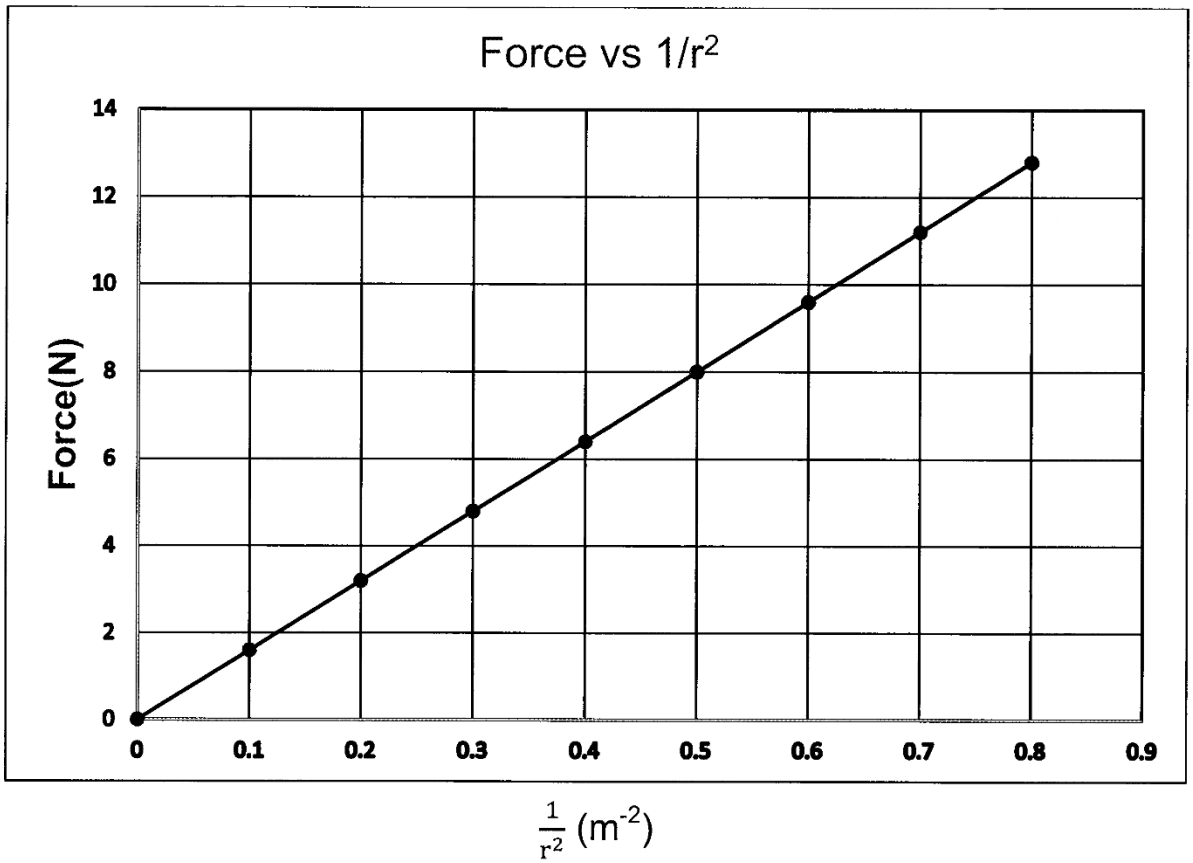
QUESTION 3

The graph below shows the relationship between the force (F) exerted by one charged particle on another and the inverse of the square of the distance ($1/r^2$) between the particles. The particles are identical and have the same charge (Q).



3.1 State Coulombs Law in words. (2)

3.2 Write down the mathematical relationship between the variables F and $\frac{1}{r^2}$. (1)

3.3 Calculate the gradient of the graph. (2)

3.4 Use the answer in question 3.3 to determine the charge on each of the particles. (4)

[9]

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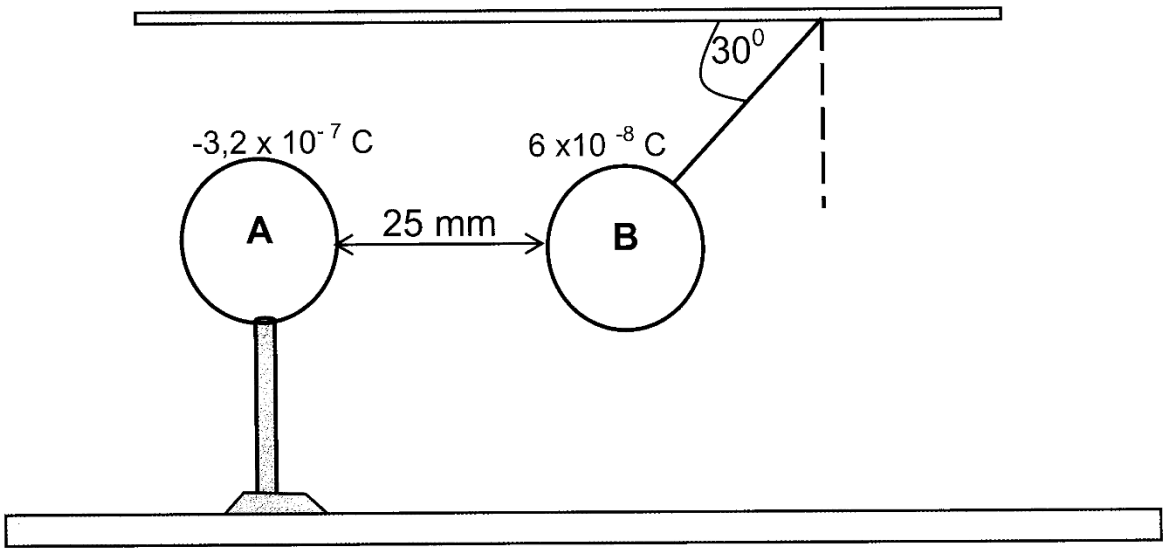
QUESTION 4

In the diagram below, A and B are two identical spheres of unknown mass. Sphere A carries a small negative charge of 3,2 x 10^{-7} C and B has a positive charge of 6 x10^{-8} C. Sphere B is attached to a string of negligible mass. When A and B are exactly 25mm apart, the string makes an angle of 30^0 with the horizontal, as shown in the diagram.

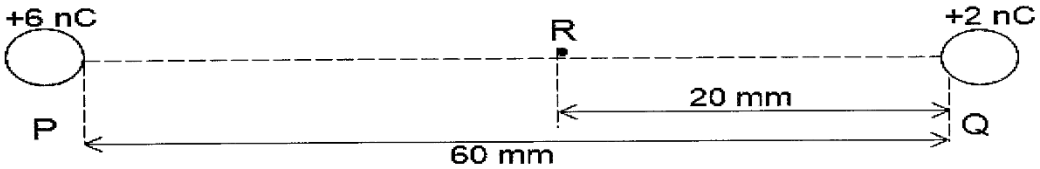


4.1.1 Give a reason why the forces acting on sphere B can be represented as a closed triangle. (1)

4.1.2 Draw the triangle of forces for sphere B. Label the forces, and indicate at least **ONE** angle in the triangle. (4)

4.1.3 Calculate the magnitude of the weight of sphere B. (5)

4.2 Two small identical spheres P and Q carry charges of +6 nC and +2 nC respectively are placed 60 mm apart as shown in the diagram below.



4.2.1 Define *electric field at a point*. (2)

4.2.2 Draw the electric field pattern for sphere P as an isolated charge. (3)

4.2.3 *R* is a point on the line joining the two spheres 20 mm from sphere Q. Calculate the magnitude of the net electric field at point R. (5)

4.2.4 An electron is placed at point R. Calculate the NET force experienced by the electron by using the answer from question 4.2.3. (3)

[23]

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QUESTION 5

The table below shows the boiling points of ammonia and water respectively.

NAME OF SUBSTANCE	BOILING POINT (°C)
Ammonia	– 33°C
Water	100°C

5.1 Define *boiling point*. (2)

5.2 Explain the difference in boiling points between ammonia and water. (4)

5.3 Which substance will have a lower vapour pressure? Give a reason for the answer. (2)

[8]

QUESTION 6

Aspartame is an artificial sweetener with the following chemical composition:

57,14% carbon; 6,16% hydrogen; 9,52% nitrogen; 27,18% oxygen.

6.1 Define *empirical formula*. (2)

6.2 Determine the empirical formula of Aspartame. (5)

6.3 If the empirical formula is the same as the molecular formula of Aspartame, calculate the molar mass of Aspartame. (1)

[8]

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QUESTION 7

0,8 g of Ozone(O_3) is reacted with 0,75 g of nitrogen (II) oxide (NO) according to the following reaction:

$$O_3(g) + NO(g) \longrightarrow O_2(g) + NO_2(g)$$

7.1 Define *limiting reagent*. (2)

7.2 Identify the limiting reagent in this reaction the means of a suitable calculation. (4)

7.3 Calculate the EXPECTED number of moles of oxygen gas that will be produced in this reaction. (2)

7.4 Hence, calculate the maximum number of moles of gas in the container when the reaction is complete. (3)

7.5 Calculate the percentage yield if only 0,48g of oxygen gas was actually produced on completion of the reaction. (4)

[15]

QUESTION 8

8.1 Most antacid tablets contain sodium bicarbonate, better known as baking soda ($NaHCO_3$), which helps to neutralize **excess** hydrochloric acid in the stomach. The balanced equation for this neutralization reaction is:

$$NaHCO_3(s) + HC\ell(aq) \longrightarrow NaC\ell(aq) + H_2O(\ell) + CO_2(g)$$

One antacid tablet contains 1,35 g of $NaHCO_3$.
Assume that the antacid contains no other substance that will react with the $HC\ell$.

8.1.1 Define the term *concentration*. (2)

8.1.2 If the concentration of hydrochloric acid in the stomach is 1,0 $mol.dm^{-3}$, calculate the volume of acid that ONE such tablet will neutralize. (5)

8.1.3 Calculate the mass of carbon dioxide produced from one antacid tablet. (3)

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8.2 Learners attempt to find the percentage purity of a sample of calcium carbonate in the school laboratory.
To do this they add 1,5g of **impure** calcium carbonate to **excess** hydrochloric acid of concentration 2 $mol.dm^{-3}$.
The carbon dioxide they collected on completion of the reaction occupied a volume of 0,246 dm^3 at STP.

$$CaCO_3(s) + 2\,HC\ell\,(aq) \longrightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2\,(g)$$

Calculate the percentage purity of the calcium carbonate. (5)

[15]

TOTAL: 100 MARKS

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DATA FOR PHYSICAL SCIENCES GRADE 11

PHYSICS

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	9,8 $m \cdot s^{-2}$
Coulomb's constant	k	9,0 x 10 $N \cdot m \cdot C$
Charge on electron	e	$-1,6 \times 10^{-19}$ C
Electron mass	m_e	$9,11 \times 10^{-31}$ kg

TABLE 2 : FORMULAE

ELECTROSTATICS

$F = \frac{kQ_1Q_2}{r^2}$ $(k = 9,0 \times 10^9 N \cdot m^2 \cdot C^{-2})$	$E = \frac{F}{q}$
$E = \frac{kQ}{r^2}$ $(k = 9,0 \times 10^9 N \cdot m^2 \cdot C^{-2})$	$V = \frac{W}{Q}$

TABLE 3: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Avogadro's constant	N_A	$6,02 \times 10^{23}$ mol^{-1}
Molar gas constant	R	8,31 $J \cdot K^{-1} \cdot mol^{-1}$
Standard pressure	p^θ	$1,013 \times 10^5$ Pa
Standard temperature	T^θ	273 K

TABLE 4: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$

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TABLE 3: THE PERIODIC TABLE OF ELEMENTS

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
2,1 **1** H 1																	**2** He 4
1,0 **3** Li 7	1,5 **4** Be 9											2,0 **5** B 11	2,5 **6** C 12	3,0 **7** N 14	3,5 **8** O 16	4,0 **9** F 19	**10** Ne 20
0,9 **11** Na 23	1,2 **12** Mg 24											1,5 **13** Aℓ 27	1,8 **14** Si 28	2,1 **15** P 31	2,5 **16** S 32	3,0 **17** Cℓ 35,5	**18** Ar 40
0,8 **19** K 39	1,0 **20** Ca 40	1,3 **21** Sc 45	1,5 **22** Ti 48	1,6 **23** V 51	1,6 **24** Cr 52	1,5 **25** Mn 55	1,8 **26** Fe 56	1,8 **27** Co 59	1,8 **28** Ni 59	1,9 **29** Cu 63,5	1,6 **30** Zn 65	1,6 **31** Ga 70	1,8 **32** Ge 73	2,0 **33** As 75	2,4 **34** Se 79	2,8 **35** Br 80	**36** Kr 84
0,8 **37** Rb 86	1,0 **38** Sr 88	1,2 **39** Y 89	1,4 **40** Zr 91	**41** Nb 92	1,8 **42** Mo 96	1,9 **43** Tc	2,2 **44** Ru 101	2,2 **45** Rh 103	2,2 **46** Pd 106	1,9 **47** Ag 108	1,7 **48** Cd 112	1,7 **49** In 115	1,8 **50** Sn 119	1,9 **51** Sb 122	2,1 **52** Te 128	2,5 **53** I 127	**54** Xe 131
0,7 **55** Cs 133	0,9 **56** Ba 137	**57** La 139	1,6 **72** Hf 179	**73** Ta 181	**74** W 184	**75** Re 186	**76** Os 190	**77** Ir 192	**78** Pt 195	**79** Au 197	**80** Hg 201	1,8 **81** Tℓ 204	1,8 **82** Pb 207	1,9 **83** Bi 209	2,0 **84** Po	2,5 **85** At	**86** Rn
0,7 **87** Fr	0,9 **88** Ra 226	**89** Ac															

58 Ce 140	**59** Pr 141	**60** Nd 144	**61** Pm	**62** Sm 150	**63** Eu 152	**64** Gd 157	**65** Tb 159	**66** Dy 163	**67** Ho 165	**68** Er 167	**69** Tm 169	**70** Yb 173	**71** Lu 175
90 Th 232	**91** Pa	**92** U 238	**93** Np	**94** Pu	**95** Am	**96** Cm	**97** Bk	**98** Cf	**99** Es	**100** Fm	**101** Md	**102** No	**103** Lr

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*

Electronegativity / *Elektronegatiwiteit*

Symbol / *Simbool*

Approximate relative atomic mass / *Benaderde relatiewe atoommassa*

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MARKING GUIDELINE

NB: This marking guideline consists of 7 pages.

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QUESTION 1

1.1 B ✓✓
1.2 B ✓✓
1.3 A ✓✓
1.4 D✓✓
1.5 D ✓✓
1.6 C✓✓

[12]

QUESTION 2

2.1 They attract each other✓because they have opposite charges. ✓ (2)

2. 2 The net/total charge of an isolated system remains constant during any physical process✓✓ (2)

2.3

$$Qafter = \frac{Q_1 + Q_2}{2}$$

$$= \frac{(+5 + (-11)}{2} \checkmark$$

Q = – 3 nC✓ (2)

2.4 Q ✓ (1)

2.5 **Positive marking from question 2.1.3**

+ 5 + x = – 3 ✓
x = – 8 nC

OR

–11 – x = – 3✓
x = – 8 nC

$$n = \frac{Q}{e}$$

$$= \frac{8x10^{-9}}{1{,}6\,x10^{-19}} \checkmark$$

= 5 x 10^{10} ✓ electrons (3)

[10]

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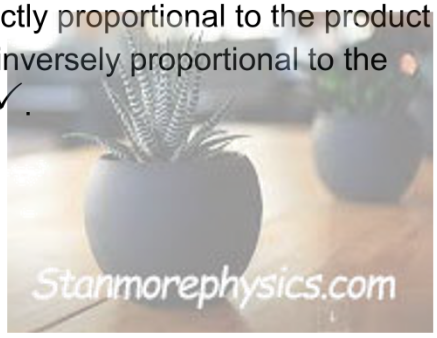
QUESTION 3

3.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges ✓ and inversely proportional to the square of the distance (r) between them ✓. (2)



3.2 They are directly proportional ✓ (1)

3.3 Gradient = $\frac{\Delta F}{\Delta \frac{1}{r^2}}$

$= \frac{8-0}{0,5-0}$ ✓

= 16 ✓ (Accept range 15-17) (2)

3.4 **Positive marking from question 3.3**

$F = \frac{kQ_1Q_2}{r^2}$ ✓

16 ✓ = 9 x 10^9 x Q^2 ✓

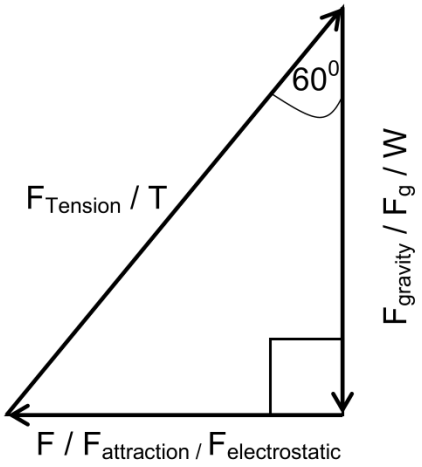
Q = 4,22 x 10^{-5} C ✓ (4)

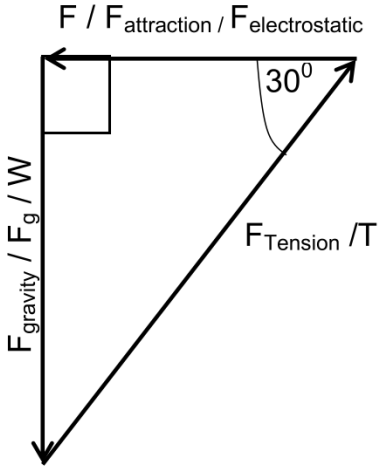
[9]

QUESTION 4

4.1.1 The net force acting on sphere B is zero. ✓ (1)

4.1.2





NB : Ignore the sizes of the force vectors.

Marking Rubric : Triangle of forces	
Criteria	Mark allocation
Forces correctly drawn and labelled	3 x 1 = 3
angle correctly shown	1

(4)

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4.1.3 $F = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9 \times 10^9)(3{,}2 \times 10^{-7})(6 \times 10^{-8})}{(0{,}025)^2}$ ✓✓

$= 0{,}2765$ N

$\tan\theta = \frac{F}{Fgravity}$

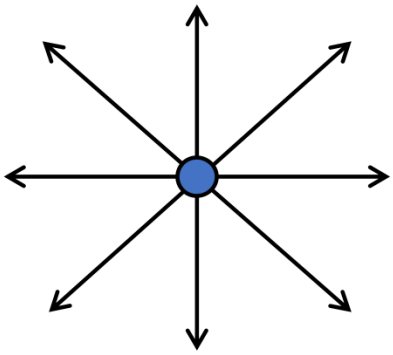
$\tan 60^0$ ✓ $= \frac{0{,}2765}{Fg}$ ✓

$Fg = 0{,}159N$ ✓ (5)

4.2

4.2.1 The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point ✓✓ (2 or 0) (2)

4.2.2



Marking Rubric : Sketch of Electric field	
Criteria	Mark allocation
Correct direction of field lines	1
Shape of electric field	1
No field lines crossing each other/ or in the sphere	1
NB: if shape incorrect	0/3

(3)

4.2.3 $E(P \rightarrow R) = \frac{kQ}{r^2}$

$= \frac{9 \times 10^9 \times 6 \times 10^{-9}}{(0{,}040)^2}$ ✓

$= 33750\ NC^{-1}$

$E(Q \rightarrow R) = \frac{kQ}{r^2}$

$= \frac{9 \times 10^9 \times 2 \times 10^{-9}}{(0{,}020)^2}$ ✓

$= 45000\ NC^{-1}$

$E_{Net} = \frac{45000 - 33\,750}{}$ ✓

$= 11\,250\ NC^{-1}$ ✓

Accept : $33\,750 - 45\,000$ ✓

$= -11\,250\ NC^{-1}$ ✓ (Ignore sign of answer) (5)

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4.2.4 (Positive marking from question 4.2.3)

$F = E \cdot Q$ ✓

$= (11\ 250)(1{,}6 \times 10^{-19})$ ✓

$= 1{,}8 \times 10^{-15}$ N ✓ (3)

[23]

QUESTION 5

5.1 The temperature at which the vapour pressure of a substance equals atmospheric pressure. ✓✓ (2)

5.2 Ammonia has ONE site for hydrogen bonding ✓while water has TWO sites for hydrogen bonding.✓
Therefore, force of attraction between water molecules are stronger than that of ammonia molecules. ✓
Thus more energy is needed to overcome intermolecular forces in water, ✓ therefore higher boiling point. (4)

5.3 Water. ✓
Higher boiling point. ✓ (2)
[8]

QUESTION 6

6.1 Simplest ratio of elements in a compound. ✓✓ (2)

6.2

	C	H	N	O	
Mass	57,14g	6,16g	9,52g	27,18g	
n = m/M	$\frac{57{,}14}{12}$	$\frac{6{,}16}{1}$	$\frac{9{,}52}{14}$	$\frac{27{,}18}{16}$	✓
No of moles	4,76	6,16	0,68	1,70	✓
Divide by smallest	$\frac{4{,}76}{0{,}68}$	$\frac{6{,}16}{0{,}68}$	$\frac{0{,}68}{0{,}68}$	$\frac{1{,}70}{0{,}68}$	✓
Ratio	7	9	1	2,5	✓
	14	18	2	5	X2

Empirical Formula: $C_{14}H_{18}N_2O_5$ ✓

(5)

6.3 $M = 14(12) + 18(1) + 2(14) + 5(16) = 294\ g.mol^{-1}$ ✓ (1)

[8]

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QUESTION 7

7.1 The reactant that is completely used up in a chemical reaction.✓✓ (2)

7.2

O_3	NO
n = m/M ✓	n = m/M
= 0,8 / 48	= 0,75 / 30
= 0,02mol ✓	= 0,03mol✓

Therefore O_3 is limiting✓ (4)

7.3 $n\,O_3 : nO_2$
$1 : 1$ ✓
Therefore $nO_2 = n\,O_3$
$= 0,02mol$✓ (2)

7.4

	$O_3(g)$:	$NO(g)$:	$O_2(g)$:	$NO_2(g)$
Ratio	1	1	1	1
Moles at end	0	0,01	0,02	0,02

Total moles of gas at end $= nNO + nO_2 + nNO_2$
$= 0,01$ ✓ $+ 0,02 + 0,02$ ✓
$= 0,05$ mol ✓ (3)

7.5 **Positive marking from 7.3**

Mass of $O_2 = nM$
$= (0,02)(32)$ ✓
$= 0,64g$ ✓

Percentage yield $= \frac{\text{actual yield}}{\text{theoretical yield}} \times \frac{100}{1}$ (4)

$= \frac{0,48}{0,64} \times \frac{100}{1}$ ✓

$= 75\%$ ✓

[15]

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QUESTION 8

8.1.1 The number of moles per unit volume of a substance. ✓✓ (2)

8.1.2 $n\ NaHCO_3 = m/M$
$= \frac{1,35}{84}$ ✓
$= 0,016$ mol

$M = 23 + 1 + 12 + 3(16)$
$= 84\ g.mol^{-1}$

$n\ NaHCO_3 : nHCl$
$1 : 1$ ✓
Therefore, $nHCl = 0,016$ mol ✓

$n = C \times V$
$0,016 = 1,0 \times V$ ✓
$V = 0,016\ dm^{-3}$ ✓ (5)

8.1.3 $n\ NaHCO_3 : nCO_2$
$1 : 1$ ✓
$n = m/M$
$0,016 = \frac{m}{44}$ ✓
$m = 0,70g$ ✓ (3)

8.2 $n\ CO_2 = m/M$
$= \frac{0,5}{44}$ ✓
$= 0,011$ mol

$M = 12 + 2(16)$
$= 44\ g.mol^{-1}$

$n\ CaCO_3 : nCO_2$
$1 : 1$ ✓
Therefore: $n\ CaCO_3 = 0,011$mol

$m = nM$
$= (0,011)(100)$ ✓
$= 1,10g$

$M = 40 + 12 + 3(16)$
$= 100\ g.mol^{-1}$

$\%\ purity = \frac{\text{Pure sample}}{\text{Impure sample}} \times \frac{100}{1}$
$= \frac{1,10}{1,5} \times \frac{100}{1}$ ✓
$= 73,33\%$ ✓ (5)

[15]

TOTAL MARKS: 100

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